SOLAR INDICES BULLETIN

SEPTEMBER 2001

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ISSN 1046-1914

♦ SOLAR RADIO EMISSIONS

The quiet Sun emits radio energy with a slowly varying intensity. These radio fluxes, which stem from atmospheric layers high in the chromosphere and low in the corona, change gradually from day-to-day, in response to the number and size of spot groups on the solar disk. The table below gives daily measurements of this slowly varying emission at selected wavelengths between about 1 and 100 centimeters. Many observatories record quiet-sun radio fluxes at the same local time each day and correct them to within a few percent for factors such as antenna gain, bursts in progress, atmospheric absorption, and sky background temperature. At 2800 megahertz (10.7 centimeters) flux observations summed over the Sun's disk have been made continuously since February 1947.

♦ SOLAR FLUX TABLE

Numbers in parentheses in the column headings below denote frequencies in megahertz. Each entry is given in solar flux units--a measure of energy received per unit time, per unit area, per unit frequency interval. One solar flux unit equals 10^{-22} J/m^{2}Hz sec.

During low periods of solar activity, the flux never falls to zero, because the Sun emits at all wavelengths with or without the presence of spots. The lowest daily Ottawa flux since 1947 occurred on November 3, 1954. On that day the <u>observed</u> noon value dropped to 62.6 units; the highest <u>observed</u> value of 457.0 occurred on April 7, 1947.

The preliminary <u>observed</u> and <u>adjusted</u> Penticton fluxes tabulated here are the "Series C" values reported by Canada's Dominion Radio Astrophysical Observatory in Penticton, British Columbia. <u>Observed</u> numbers are less refined, since they contain fluctuations as large as ±7% from the continuously changing sun-earth distance. <u>Adjusted</u> fluxes have this variation removed; they show the energy received at the mean distance between the Sun and Earth. Gaps in the Palehua, Hawaii (PALE), data reflect equipment problems. Fluxes measured either at Sagamore Hill, Massachusetts, or at San Vito, Italy, will be substituted for frequencies at which many Palehua values are missing.

SEPTEMBER 2001 PRELIMINARY SUNSPOT NUMBERS AND SOLAR RADIO FLUX

Day	Sunspot Number Intl	Obs Flux Pentic (2800)	Solar Flux Adjusted to 1 Astronomical Unit PALE (15400)	PALE (8800)	PALE (4995)	Pentic (2800)	PALE (2695)	PALE (1415)	PALE (610)	PALE (410)	PALE (245)
01	103	184	560	315	226	187	172	122	59	45	24
02	106	183	535	304	221	186	167	119	58	45	40
03	120	199	535	304	221	202	167	119	58	45	40
04	108	218	593	378	286	221	211	137	65	48	52
05	120	218	564	359	274	221	208	134	62	44	21
06	141	222	584	378	288	225	205	134	65	53	54
07	166	226	582	398	314	229	226	135	66	52	47
08	182	250	561	368	309	253	226	145	64	44	22
09	166	236	590	379	305	239	225	146	64	44	23
10	150	245	588	363	299	248	233	144	64	48	24
11	126	250	591	386	313	253	233	146	63	48	31
12	149	235	592	378	306	238	229	148	68	60	41
13	150	240	580	351	281	243	216	141	59	41	24
14	148	237	573	352	328	240	258	163	52	49	44
15	130	219	570	340	264	221	210	137	58	41	22
16	121	207	565	345	250	209	192	126	60	43	27
17	112	199	563	357	252	200	183	122	61	42	22
18	136	204	571	314	237	205	185	129	62	47	40
19	143	199	557	348	248	200	178	134	63	44	25
20	183	227	574	334	264	228	206	146	61	46	13
21	173	239	581	317	269	240	209	144	66	46	33
22	164	255	576	381	311	256	246	160	66	44	35
23	186	259	583	390	319	260	240	154	67	45	23
24	200	279	597	421	329	280	249	167	71	45	22
25	193	275	594	383	319	276	258	157	67	44	25
26	175	283	571	320	281	284	245	156	70	51	35
27	176	270	601	402	318	271	237	162	70	48	23
28	170	266	613	437	355	267	276	164	72	60	46
29	159	240	512	303	256	240	225	135	66	43	26
30	165	236	571	349	288	236	218	154	70	47	30
31											
Mean	150.7	233	574	358	284	235	218	143	64	47	31

AUG 2001 FINAL FLUX

Day	Observed Pentic (2800)	Adjusted Pentic (2800)
01	120.2	123.8
02	120.8	124.3
03	131.6	135.5
04	148.4	152.7
05	156.0	160.5
06	163.7	168.3
07	166.3	171.0
08	166.9	171.5
09	163.3	167.8
10	160.3	164.7
11	165.0	169.5
12	159.8	164.0
13	151.5	155.5
14	147.3	151.1
15	146.7	150.5
16	142.6	146.2
17	144.9	148.4
18	156.1	159.9
19	157.5	161.3
20	156.1	159.8
21	160.2	163.9
22	161.5	165.2
23	169.7	173.4
24	174.9	178.7
25	199.0	203.2
26	189.9	193.8
27	192.0	195.9
28	199.2	203.1
29	197.0	200.9
30	199.2	203.0
31	188.7	192.2
Mean	163.1	167.1

♦ SUNSPOT COUNTS

In 1848 the Swiss astronomer Johann Rudolph Wolf introduced a daily measurement of sunspot number. His method, which is still used today, counts the total number of spots visible on the face of the Sun and the number of groups into which they cluster, because neither quantity alone satisfactorily measures the level of sunspot activity.

An observer computes a daily sunspot number by multiplying his estimated number of groups by ten and then adding this product to his total count of individual spots. Results, however, vary greatly, since the measurement strongly depends on observer interpretation the observing site. Moreover, the use of Earth as a platform from which to record these numbers contributes to their variability, too, because the sun rotates and the evolving spot groups are distributed unevenly across solar longitudes. To compensate for these limitations, each daily international number is computed as a weighted average of measurements made from a network of cooperating observatories. The international sunspot numbers tabulated on page 1 are provisional values taken from a bulletin prepared monthly by Pierre Cugnon of the SUNSPOT INDEX DATA CENTER, 3 avenue Circulaire, B-1180 BRUXELLES, BELGIUM. The September 2001 data combine observations from 35 stations. http://www.oma.be/KSB-ORB/SIDC/index.html.

♦ HISTORICAL SUNSPOT COUNTS

How do sunspot numbers in the table on page 1 compare to the largest values ever recorded? The highest daily count on record occurred December 24-25, 1957. On each of those days the sunspot number totaled 355. In contrast, during years near the spot cycle minimum, the count can fall to zero. Today, much more sophisticated measurements of solar activity are made routinely, but none has the link with the past that sunspot numbers have. Our archives, for example, include reconstructed daily values from January 8, 1818; monthly means from January 1749; and yearly means beginning in 1700.

SMOOTHED (OBSERVED AND PREDICTED) SUNSPOT NUMBERS: CYCLES 22 AND 23

1991	148	148	147	147	146	145	146	147	145	142	138	132	144
1992	124	115	108	103	100	97	91	84	80	76	74	73	94
1993	71	69	67	64	60	56	55	52	48	45	41	38	56
1994	37	35	34	34	33	31	29	27	27	27	26	26	30
1995	24	23	22	21	19	18	17	15	13	12	11	11	17
1996	10	10	10	9	8*	9	8	8	8	9**	10	10	9
1997	10	11	14	17	18	20	23	25	28	32	35	39	23
1998	44	49	53	57	59	62	65	68	70	71	73	78	62
1999	83	85	84	86	91	93	94	98	103	108	111	111	96
2000	113	117	120	121	119	119	120	119	116	115	113	112	117
2001	109	104	105	104 (6)	104 (12)	103 (13)	102 (12)	102 (14)	101 (16)	100 (17)	99 (18)	98 (18)	103 (11)
2002	97 (19)	96 (20)	94 (21)	92 (22)	90 (21)	88 (20)	86 (20)	83 (20)	81 (20)	79 (20)	76 (20)	74 (17)	86 (20)
2003	71 (15)	69 (13)	67 (13)	65 (14)	62 (15)	60 (16)	58 (17)	57 (17)	55 (18)	53 (19)	51 (20)	50 (22)	60 (17)

*May 1996 marks Cycle 22's mathematical minimum.
**October 1996 marks the consensus Cycle 22 minimum which NGDC is now using.

♦ SUNSPOT NUMBER PREDICTIONS

For the end of Solar Cycle 22, and the beginning of Cycle 23, the table gives <u>smoothed</u> sunspot numbers up to the one calculated that first uses the most recently measured monthly mean. These smoothed, observed values are based on final, unsmoothed monthly means through June 2001 and on provisional ones thereafter. We compute a smoothed monthly mean by forming the arithmetic average of two sequential 12-month running means of monthly means.

Table entries with numbers in parentheses below them denote predictions by the McNish-Lincoln method. This method estimates future numbers by adding a correction to the mean of all cycles that is proportional to the departure of earlier values of the current cycle from the mean cycle. (See page 9 in the July 1987 supplement to *Solar-Geophysical Data*). We use and predict only smoothed monthly means, because we believe the errors are too great to estimate any values more precise. In the table above, adding the number in parentheses to the predicted value generates the upper limit of the 90% confidence interval; subtracting the number from the predicted value generates the lower limit. Consider, for example the March 2002 prediction. There exists a 90% chance that in March 2002 the actual smoothed sunspot number will fall somewhere between 73 and 115.

<u>The McNish-Lincoln prediction method generates useful estimates of smoothed, monthly mean sunspot numbers for no more than 12 months ahead.</u> Beyond a year these predictions regress rapidly toward the mean of all 13 cycles used in the computation. Moreover, the method is very sensitive to the date defined as the beginning of the current sunspot cycle, that is, to the date of the most recent sunspot minimum. The new cycle predictions tabulated above are based on the consensus minimum value of 8.8 that occurred in October 1996. For solar maximum discussions, visit http://www.sec.noaa.gov.